# CONFERENCE ON DISARMAMENT

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PROGRESS REPORT TO THE CONFERENCE ON DISARMAMENT ON THE FORTIETH SESSION OF THE AD HOC GROUP OF SCIENTIFIC EXPERTS TO CONSIDER INTERNATIONAL COOPERATIVE MEASURES TO DETECT AND IDENTIFY SEISMIC EVENTS

1. The Ad Hoc Group of Scientific Experts to Consider International Cooperative Measures to Detect and Identify Seismic Events, initially established in pursuance of the decision taken by the Conference of the Committee on Disarmament on 22 July 1976, held its fortieth formal session from 20 February to 3 March 1995, in the Palais des Nations, Geneva, under the Chairmanship of Dr. Ola Dahlman of Sweden. This was the thirty-second session of the Group, convened under its new mandate by the decision of the Committee on Disarmament at its 48th meeting on 7 August 1979.

2. The Ad Hoc Group is open to all Member States of the Conference on Disarmament. It is also open on a standing basis to all non-Member States which have been invited upon their request by the Conference on Disarmament to participate in its work. Accordingly, scientific experts and representatives of the following Member States of the Conference on Disarmament participated in the session: Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, China, France, Germany, Hungary, India, Italy, Japan, Mongolia, the Netherlands, Pakistan, Poland, the Russian Federation, Sweden, the United Kingdom of Great Britain and Northern Ireland and the United States of America.

3. Scientific experts and representatives from the following non-Member States of the Conference on Disarmament participated in the session: Austria, the Czech Republic, Denmark, Finland, Israel, the Republic of Korea, New Zealand, Norway, Spain, Switzerland and Turkey.

4. During the session 49 papers containing information on national investigations related to the work of the Group were presented by experts from Argentina, Australia, Austria, Brazil, Bulgaria, Canada, China, the Czech Republic, Denmark, Finland, France, Germany, Hungary, India, Israel, Italy, Japan, Mongolia, the Netherlands, New Zealand, Norway, Romania, the Russian Federation, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the United States of America.

5. The Group reviewed initial results from its Third Technical Test, GSETT-3, which successfully began full-scale operations on 1 January 1995. A report summarizing the initial experience from the full-scale phase is annexed to this Progress Report.

6. As part of its review of GSETT-3 the Ad Hoc Group conducted in-depth discussions on the results of the three working groups that it has established to deal with the planning, operation and evaluation of the experiment. Several meetings of these working groups were held during the session. Summaries of the status of the efforts and plans of these three working groups are included in annex 3.

7. The Group also discussed its future plans for GSETT-3. The Group agreed that continuation of GSETT-3 for an extended period of time along the operational plans outlined in CD/1254 would be important to progressively modify the system to meet the International Monitoring System (IMS) design, as decisions are made by the CD on the seismic component of a future IMS. This would also ensure continued training of an international staff and continued provision of practical advice to the CD. In addition, the GSE could cooperate in experiments to demonstrate the synergy between the seismic IMS and other non-seismic IMS components, if requested by the NTB AHC. For financial planning purposes, countries participating in GSETT-3 should be prepared to support their national facilities and communications links at least through 1996.

8. It was noted that facilities are incomplete for some of the stations envisioned as part of the GSETT-3 monitoring network (CD/1254). It is of particular importance to ensure financial resources for continuous data transmission, and for operation of other facilities during GSETT-3. Countries are encouraged to assist by providing technical and financial assistance in these areas to other countries whose participation is essential.

9. The Ad Hoc Group received and appreciated a briefing from the Chairman of the Nuclear Test Ban Committee's Working Group on Verification. Upon invitation by the Chairman, the Ad Hoc Group gave a presentation to the Working Group of the GSETT-3 experiment.

10. As reported in the last Progress Report (CD/1270), the Ad Hoc Group received a letter from the International Seismological Centre (ISC) requesting receipt of GSETT-3 seismic bulletins and phase data on a regular basis. Addressing the broader issue, the Ad Hoc Group agreed that GSETT-3 data will be a valuable resource to the broader seismological community, and supported the concept that National Data Centers could, at their discretion, be the conduit through which GSETT-3 data are provided to individuals and organizations not directly participating in GSETT-3. In this capacity, the UK has offered to provide the requested data to the ISC in a manner agreeable to both parties.

11. The Ad Hoc Group suggests that its next session, subject to approval by the Conference on Disarmament, should be convened from 7 to 18 August 1995. The main task during the next session will be to review and evaluate results from the full-scale phase of GSETT-3. The Group is prepared to meet during the second part of the session of the Conference on Disarmament, if so requested by the CD in view of the work of the Ad Hoc Committee on a Nuclear Test Ban. A draft work programme for the next session is presented in Annex 1. The work programme will be tailored to meet as much as practicable the information needs of the Ad Hoc Committee on a Nuclear Test Ban and its Working Group on Verification.

## Annex 1

### Draft work programme for the next (41st) session

1. Continued review of results from the full-scale GSETT-3 testing:

   - IDC reports
   - National reports by participants

2. Continued evaluation of the GSETT-3 system and its results

3. Discussion of modifications to GSETT-3 procedures needed in the light of these experiences

4. Presentation and review of national investigations into relevant matters

5. Discussion of future plans

6. Answer possible questions relating to GSETT-3 from the NTB Ad Hoc Committee or its Working Group on Verification

7. Submission of a progress report to the CD

8. Other matters

Annex 2

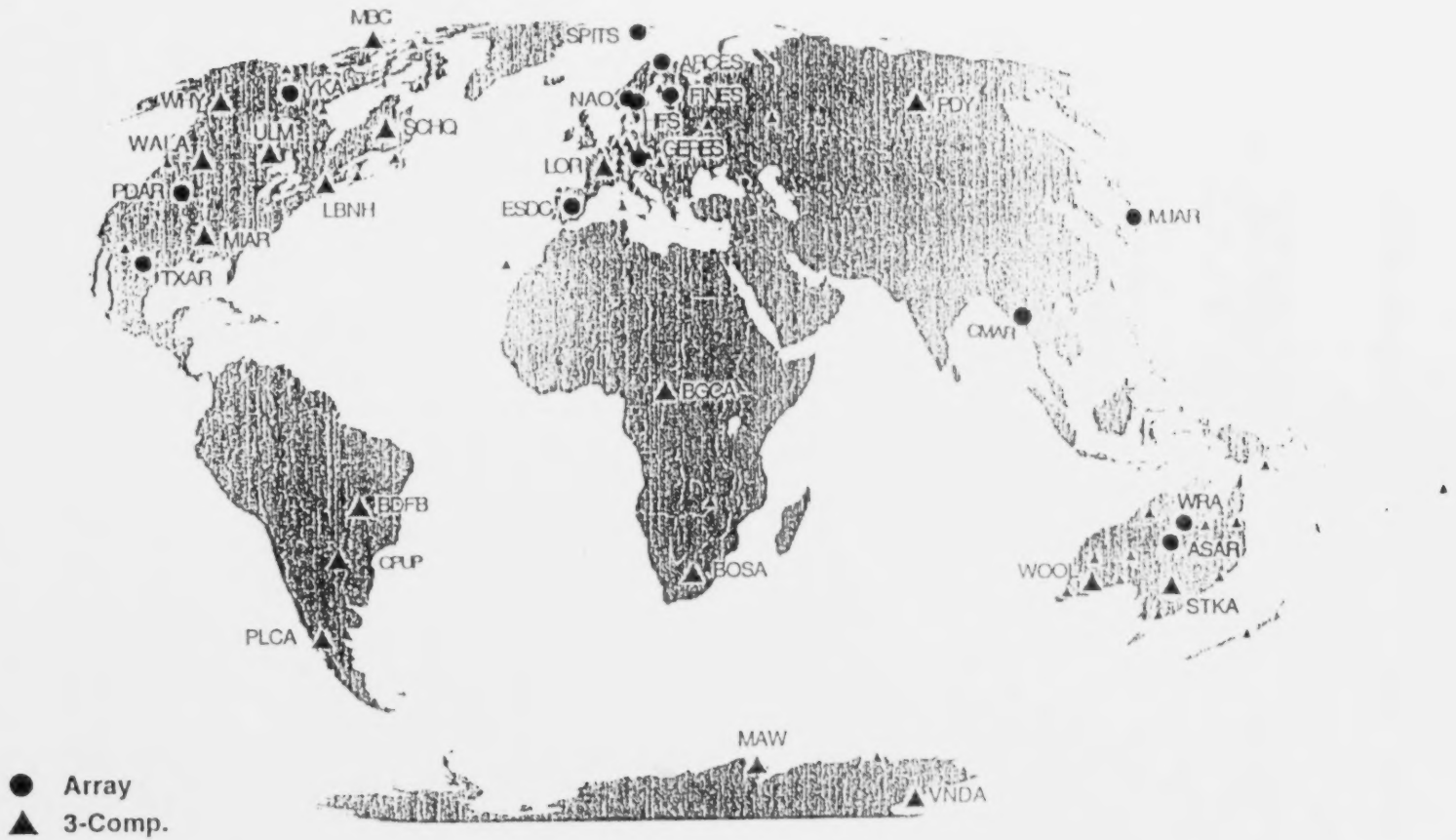
Status of GSETT-3 Station and Gamma Data Commitments
as of 1 March 1995

| COUNTRY | Alpha Stations Envisaged by GSE | Beta Stations Offered | Station commit-ment Status | Data Available to IDC | Gamma Data Committed |
|---|---|---|---|---|---|
| Argentina | 1 | 1 | committed | 1994/ July 1995 | yes |
| Australia | 5 | 11 | committed | 1994 | yes |
| Austria | 0 | 1 | lacking | unknown | - |
| Belgium | 0 | 0 | not applicable | not applicable | yes |
| Bolivia | 1 | - | lacking | unknown | - |
| Botswana | 1 | - | lacking | unknown | - |
| Brazil | 1 | 2 | committed/ lacking | 1994/1995 | - |
| Bulgaria | 0 | 1 | committed | July 1995 | yes |
| Canada | 6 | 18 | committed | 1994 | yes |
| Cen. Afr. Republic | 1 | - | committed | 1994 | - |
| Chile | 0 | 1 | committed | - | - |
| China | 3 | 0 | committed | unknown | - |
| Cook Islands | 0 | 1 | committed | 1994 | - |
| Colombia | 1 | 0 | committed | mid-1995 | - |
| Costa Rica | 0 | 1 | committed | - | - |
| Czech Republic | 0 | 1 | committed | 1994 | yes |
| Denmark | 1 | - | lacking | July 1995 | yes |
| Egypt | 1 | 0 | lacking | unknown | - |
| Ethiopia | 0 | 1 | committed | - | - |
| Finland | 1 | 2 | committed | 1994 | yes |
| France | 1 | 0 | committed | Jan.1995 | yes |
| Germany | 1 | 9 | committed | 1994 | - |
| Hungary | 0 | 1 | committed | 1994 | yes |

| | | | | | |
|---|---|---|---|---|---|
| Iceland | 0 | 1 | committed | - | - |
| India | 1 | 0 | committed | May 1995 | - |
| Indonesia | 1 | - | lacking | unknown | - |
| Iran | 1 | 1 | lacking | June 1995 | yes |
| Israel | 0 | 1 | committed | March 1995 | yes |
| Italy | 0 | 2 | committed | 1994 | yes |
| Ivory Coast | 1 | - | committed | March 1995 | - |
| Japan | 1 | 7 | committed | 1994 | yes |
| Kazakhstan | 1 | - | lacking | unknown | - |
| Kenya | 1 | - | lacking | unknown | - |
| Rep. of Korea | 1 | - | lacking | unknown | - |
| Mexico | 1 | 2 | lacking | unknown | - |
| Mongolia | 1 | 1 | committed | unknown | - |
| Netherlands | 0 | 1 | committed | 1994 | yes |
| N.Africa (XAF) | 1 | - | lacking | unknown | - |
| New Zealand | 0 | 1 | committed | 1994 | yes |
| Norway | 3 | 1 | committed | 1994 | yes |
| Pakistan | 1 | 1 | committed | 1995 | - |
| Papua New Guinea | 1 | - | committed[1] | Jan. 1995 | - |
| Paraguay | 1 | - | committed | 1994 | - |
| Peru | 0 | 1 | committed | 1995 | yes |
| Philippines | 0 | 1 | committed | - | - |
| Poland | 0 | 1 | lacking | unknown | yes |
| Portugal | 0 | 1 | committed | - | - |
| Romania | 0 | 1 | committed | 1995 | yes |
| Russian Federation | 5 | 5 | committed | 1994 | - |
| Seychelles | 0 | 1 | committed | - | - |
| South Africa | 1 | 1 | committed | 1994/1995 | yes |
| Spain | 1 | 2 | committed | Jan. 1995 | yes |
| Sweden | 1 | 0 | committed | Jan. 1995 | yes |
| Switzerland | 0 | 1 | committed | Jan. 1995 | yes |
| Thailand | 1 | - | committed | Feb. 1995 | - |
| Turkey | 1 | - | committed | unknown | - |

| | | | | | |
|---|---|---|---|---|---|
| Turkmenistan | 1 | - | committed | unknown | - |
| Ukraine | 0 | 1 | committed | - | - |
| United Kingdom | 0 | 2 | committed | 1994 | yes |
| United States | 7 | 12 | committed | 1994 | yes |
| Western Samoa | 0 | 1 | committed | 1994 | - |
| Zambia | 0 | 1 | committed | Jan. 1995 | - |
| **TOTAL** (Committed) | 60(49) | 102(95) | | | 26 |

# Current GSETT-3 Network




This map shows the stations of the GSETT-3 network contributing data to the IDC as of 1 March 1995. Alpha stations are indicated by large symbols and Beta stations by small ones.

## Annex 3

### Summary report on initial results of the GSETT-3 full-scale test

#### Executive Summary

On 1 January 1995, the Ad Hoc Group of Scientific Experts (GSE) Third Technical Test, GSETT-3, successfully began full-scale operations. GSETT-3, which has been described in detail in document CD/1254, is an effort to develop, test and evaluate new concepts for an experimental International Seismic Monitoring System (ISMS).

The initial phase of the GSETT-3 full-scale operations has been successful. The seismic monitoring system has achieved the objectives of acquiring, storing and disseminating raw data. In addition many of the processed data products are available to the National Data Centers (NDCs). This is due to the dedicated efforts of many individuals, both in and outside of the GSE. Particularly noteworthy is the demonstrated capability of the International Data Center (IDC) to adhere to the strict processing schedule and the high quality requirements, even in instances of very heavy processing load due to large earthquake sequences.

While it is still too early to draw any definite conclusions, it can already be stated that GSETT-3 is fulfilling many of the requirements originally specified for the test. Some technical problems have been encountered, but they have largely been solved along the way without serious interruptions or degradation of performance. The participation is still somewhat less than originally envisaged, but it is steadily increasing. There is also a need for further developments of technical facilities at many seismograph stations and NDCs. Likewise, some existing data communication links are inadequate and must be improved. These developments are given high priority.

The GSETT-3 system is already providing an infrastructure in the form of technical facilities, including education and training of personnel, which could facilitate the implementation of a monitoring system for verifying compliance with a CTBT. GSETT-3 is also providing experience with data and services that will be needed by the national verification programs of the participating States for monitoring a CTBT.

GSETT-3 has proven its usefulness for work conducted by the IMS expert group in evaluating options for future monitoring systems. GSETT-3 is already providing data relevant to assessing the performance of various seismic monitoring networks.

Initial experience from GSETT-3 has reconfirmed that GSETT-3 will, as anticipated in CD/1254, provide the following information relating to a future International Seismic Monitoring System (ISMS):

- The station network designed for GSETT-3 represents a basis for the design of the ISMS.
- The functions and products which have been designed for the IDC is the guide to the functions and products required from the ISMS for monitoring purposes.
- The detailed instructions and procedures developed for GSETT-3 will form a good foundation for an Operating Manual for the components of the ISMS.
- The experiences in GSETT-3 will be useful in estimating system capabilities, costs and staffing requirements, and in specifying

requirements for ISMS components such as seismic stations and facilities, telecommunications equipment, and hardware and software for NDCs and the IDC.

The system to be tested during GSETT-3 is evolutionary in nature. Additional stations, improved instrumentation and new processing methods are expected to be incorporated as the test progresses. The GSE will conduct an ongoing assessment of various system components during GSETT-3. Results will be continually incorporated into the system to improve its performance so that the system will be capable of providing the Conference on Disarmament with material relevant to the establishment and operation of a future system for monitoring of a comprehensive test ban treaty.

As GSETT-3 evolves, the results will be regularly reported to the Conference on Disarmament, and the GSETT-3 experience is expected to represent a major contribution to the advancement of a future international monitoring system under a CTBT.

1. Background

The concepts to be tested during GSETT-3 include: a single centralized International Data Center, a specifically designed high-quality seismographic network, and a modern communications system providing continuous data to the international center. As stated in CD/1254, the primary objectives of GSETT-3 are to:

- develop and test new concepts for an experimental ISMS, building upon previous experience;
- provide a practical basis upon which to furnish the Conference on Disarmament with timely technical information;
- develop an experimental system that can evolve and adapt to support future requirements that may be specified for an International Seismic Monitoring System.

GSETT-3 is an unprecedented global effort to conduct an operationally realistic test of rapid collection, distribution and processing of seismic data. It incorporates the most advanced seismic sensors, global communications, data management and data processing technologies currently available. The GSETT-3 system will need to process and disseminate a volume of data about 10 times greater than that of any existing seismic monitoring system.

While the scope of GSETT-3 is limited to seismic monitoring, the GSETT-3 system design is flexible enough to incorporate the collection, archiving and distribution of data from non-seismic techniques, for example, radioactivity, hydroacoustics and infrasound.

This report summarizes the initial experience from GSETT-3 full-scale testing. It is based on contributions from the three GSETT-3 working groups on Planning, Operations and Evaluation.

2. GSETT-3 Participation

The global seismograph network envisaged for GSETT-3 is a two-tiered network comprising the so-called Alpha and Beta seismograph stations. The Alpha stations are designed and located to provide detection and initial location of seismic events throughout the world. The station waveform data are telemetered continuously to the IDC.

The Beta stations provide supplementary data, so that events can be located and characterised with improved accuracy. Data from Beta stations

are not telemetered continuously to the IDC, but waveform segments can be retrieved automatically.

2.1 Alpha stations

As of its 39th session, the GSE envisaged an Alpha station network of 59 stations (out of which 24 are arrays), and the GSE had received formal commitments for 38 of these stations. Since that time, contacts have been made by various means with all prospective Alpha station host countries that had not yet made a commitment to participate in GSETT-3. In this regard, many missions in Geneva were visited to see what could be done to solicit further commitments. This and other work has so far resulted in eleven additional commitments, so that the number of committed Alpha stations as of 1 March 1995 is 49. Out of these, 32 are currently contributing data to the IDC, and all but two of these are fully incorporated into the IDC processing.

2.2 Beta stations

Many countries, and especially those participating in the GSE sessions, offered Beta stations for use in GSETT-3 at an early date, and as of the 39th GSE session, information had been received for a total of 93 planned such stations, out of which 76 were committed. Additional candidate Beta stations around the world that meet the technical requirements and that are of potential usefulness to GSETT-3 have been identified, in cooperation with the Federation of Digital Seismograph Networks (FDSN) and its member networks.

The GSE is seeking formal commitments for participation in GSETT-3 in direct contact with the authorities of the host countries of such candidate stations. So far, the GSE chairman has written letters to 29 such countries, and positive responses containing commitments by the respective authorities have been received from 11 countries. In some of these cases, some clarification is needed to establish whether the commitment given applies to stations that are actually accessible in conformity with Beta station requirements.

To date, the GSE has received information on 102 planned Beta stations, out of which 95 have been committed. It is conceivable that the number of Beta stations that will ultimately be used during GSETT-3 might approach 150.

A map and a table showing the current Alpha and Beta station participation status by country are annexed to the progress report.

3. GSETT-3 Operations

The highlight of GSETT-3 operations since the last GSE session was the successful start of the full-scale test at 0000 UT 1 January 1995. This start followed a flurry of activity during the last four months of 1994 as participating nations readied their seismic stations and communications links, and the GSETT-3 IDC prepared to accept the new data and a more demanding processing schedule through the acquisition of new hardware, upgraded software and highly-qualified staff. A detailed, statistical overview of IDC operations and, to a lesser extent, of station and NDC participation is provided in the bi-weekly IDC Performance Reports. These reports are available on-line electronically from the IDC World-Wide Web (WWW) server on the Internet.

3.1 Status

As Table 1 shows, there are now 28 countries actively participating in GSETT-3 by submitting data to or retrieving data from the IDC. Data are now arriving at the IDC from stations on every continent. The number of

Alpha stations sending continuous, near-realtime data to the IDC has increased from 12 to 32 since August 1994, while the number of Beta stations accessed by the IDC has grown from 21 to 44.

Communications links and data transmission software from the Alpha stations to the IDC (often through a communications hub at an NDC) have performed adequately during the full-scale test. Acquisition of data from Beta stations using direct dial-up and GSE automatic Data Request Manager (AutoDRM) message via electronic mail have proved less reliable due to problems at the IDC, NDCs and stations, though performance continues to improve. Eleven NDCs (Canada, Finland, France, Italy, New Zealand, Japan, Romania, Spain, Switzerland, United Kingdom and the United States) are submitting Gamma data in the form of independent seismic event lists. These data are typically more than a month behind realtime, and are not yet being submitted or received by the IDC in a uniform, robust manner.

| | 1 Feb 1994 | 20 Aug 1994 | 20 Feb 1995 | Plan |
|---|---|---|---|---|
| Participating Nations | 10 | 13 | 28 | >40 |
| Alpha Stations | 6 | 12 | 32 | 59 |
| Beta Stations | 13 | 21 | 44 | ~150 |
| Coverage | European | Sparse Global | Global | Global |
| NDCs Sending Gamma Data | 1 | 5 | 11 | 20-30 |
| Volume of Data/Day to IDC | 0.2 Gbytes | 1.5 Gbytes | 2.5 Gbytes | >5 Gbytes |
| Data Days/Week | 2 | 3 | 7 (24hrs/day) | 7 (24 hrs/day) |
| REB Events/day | 20 | 20 | 60 | >100 |
| REB Events Total (since Aug 1993) | 1500 | 2700 | 6800 | |
| IDC Staff (int'l) | 27(0) | 27(0) | 47(9) | 50(9) |

**Table 1**

Starting 1 January 1995, the IDC began full-scale operation seven days per week and 24 hours per day. The IDC produces automatically an Alpha Event List (AEL) based on signals detected in the realtime, continuous waveform data from Alpha stations. Beta waveform segments, which are based on AEL event locations, are then automatically retrieved and an Alpha/Beta event list (ABEL) is produced. The waveform data is then interactively reviewed to produce a Reviewed Event Bulletin (REB). The target times for completing the automatic bulletins are 1 hour (AEL) and 4 hours (ABEL) after event time. The target for the REB is two days after the end of the data day. With minor exceptions these target times have been adhered to.

To accommodate the increased number of stations and processing of data seven days per week, the IDC has added over 30 new computers, 200 Gbytes of disk, a new high-speed computer communications system and upgraded data processing and handling software, since the last GSE session. The most significant new processing software supports intelligent retrieval of Beta data, calculation of seismic body-wave magnitudes and improved interactive analysis.

The number of staff at the IDC is now 47. International staffing and training at the IDC has been an important objective of the Working Group on Operations. Following the last GSE session offers were extended to successful applicants for positions within the IDC and there are now nine international visiting experts working at the IDC. Preparation of IDC products has focused on determining the location, depth and magnitude of seismic events world-wide that can be observed at three or more stations. The IDC products are being made available according to schedule, with an automated event list completed within about 1.5 hours of the occurrence of the event, and a high-quality analyst Reviewed Event Bulletin (REB) available within 2 days after the day of the event.

There are an average of about 60 events in the REB each day. However, there have been a number of significant earthquakes during the first weeks of the full-scale test (e.g., Kobe Japan on 16 January, Columbia on 8 January, northern New Zealand on 5 February), and the aftershocks of these have resulted in REBs containing far more events, as many as 205 for the single data day of 6 February. That the system could handle the increased load, in particular on the data analysis staff, of these swarms is encouraging.

The GSETT-3 IDC is not providing identification of detected seismic events, but will soon calculate and compile agreed parameters characterizing the detected signals that may assist participating countries in identifying the source of each seismic disturbance.

Estimates of the magnitude threshold, at the 90% confidence level, for detection of an event by three stations in the current Alpha network range from mb 3.1 in Northern Europe up to mb 4.7 in the southern oceans. Typical location uncertainties for events within 2000 km of the closest station are between 40 and 50 km. Completion and calibration of the station network and processing software will reduce this uncertainty.

The data access facilities at the IDC continue to improve. Since the last session, the IDC has installed a GSE AutoDRM for electronic mail access to the IDC database. The IDC has also provided an initial capability for NDCs to establish Subscriptions. Subscriptions are standing orders for classes of data that satisfy criteria specified by the NDC and are forwarded automatically to the NDC. A preliminary World-Wide Web (WWW) server has been installed which allows NDCs to review the state-of-health, raw data, products and documentation for the GSETT-3 system over the Internet. Facilities have also been set up whereby the required information can be obtained by logging into the IDC and extracting information from the database using Structured Query Language (SQL) commands.

To achieve the full potential of the GSETT-3 experiment, additional work is needed on all aspects of the monitoring system. As deficiencies and problems have been identified and remedied, the reliability of stations, communications and IDC processing has improved. The overall operational reliability of the system and the quality of the products will be maximized if station problems are promptly reported to the personnel responsible for the fixing them, and if there is a prompt response from the station operators, regardless of the day of the week. Problem reporting procedures are documented in the Operations Manuals.

3.2 Operational Plans

A number of significant changes are expected to take place within the IDC over the next six months. It is expected that between 10 and 15 new Alpha stations, 20 - 40 new Beta stations, and Gamma data from additional NDCs will be available during this period. More robust Alpha, Beta and Gamma acquisition software will be an important accompaniment to these new data sources. New computer hardware for data processing and mass store capable of archiving over five Terabytes of data (expandable to 25 Terabytes) will be installed at the IDC.

Major upgrades to the signal processing software, automatic association and location software and knowledge-base (through IDC, Working Group on Operations, and NDC research) are expected to improve the quality of the automated event lists and ease the burden on the analysts. The IDC products will be expanded to include a number of additional event characterization parameters, including new seismic magnitudes and spectral measurements. All IDC data and products will be more easily accessible through expanded data access features within AutoDRM, Subscriptions and the WWW server.

## 4. GSETT-3 Documentation

The GSETT-3 Documentation comprises the plan for GSETT-3, technical instructions, factual description of facilities to be used, an evaluation plan and numerous technical annexes. This voluminous documentation forms the basis for operations manuals and procedures for GSETT-3. It will also contain technical summaries of IDC and station operations and ongoing evaluation results during GSETT-3. Previous experience has shown that documentation of this type is essential.

A draft version of the GSETT-3 Documentation was produced and distributed in advance of the 39th GSE session in August 1994. Based on discussions during the 39th session, as well as review of material during the past months, an updated version of this documentation has now been compiled. This updated version was distributed during this session, as CRP/243.

The structure of the overall documentation, comprising four volumes and five annexes, remains unchanged since the 39th session. New versions are now available of Volume One - Plan, Volume Two - Operations, and Volume Four - Evaluation, whereas Volume Three - Facilities, will be reassessed with respect to format and content, and was thus not distributed at this session. New versions of all five annexes have been produced.

Documentation on Operations (Volume 2: Seismic Station Operations Manual, National Data Center Operations Manual, International Data Center Operations Manual), Formats and Protocols for Data Exchange (Annex 3), the GSE Database Structure and Attributes (Annex 4) and the GSETT-3 System Security Plan (Annex 5) has been revised and redistributed as a result of comments and suggestions made by the GSE and practical experience gained through GSETT-3 operations.

The GSETT-3 Documentation in its current version provides a solid basis for the conduct and evaluation of GSETT-3. It is desirable, however, to streamline the documentation with respect to format and style, coherency and completeness, as well as removal of unnecessary overlap between the volumes, so as to meet the high expectations of the GSE for the GSETT-3 Documentation. It is thus anticipated that CRP/243/Rev.1 could appear before the start of the 41st GSE session. This revision can then also benefit from the discussions during the 40th GSE session.

A complete GSETT-3 Documentation produced along these lines should provide the CD with material that would be highly relevant to the establishment and operation of a future treaty monitoring system. In fact, much relevant material in this regard is already contained in the current version of the GSETT-3 Documentation in the form of operational manuals for stations, National Data Centers and the International Data Center.

## 5. Evaluation

The Working Group on Evaluation (WGE) visited the IDC in early January and made a preliminary evaluation of GSETT-3 at that stage, just after the start of the formal phase of the Test. This evaluation has since been updated in the light of subsequent improvements and to reflect the many national contributions presented during the GSE session, as well as the latest IDC Performance Reports.

### 5.1 Stations and communications

A preliminary analysis of the 32 Alpha stations that were on-line to the IDC on February 20 shows that almost all are of high quality, with low noise levels and consequently a high capacity for detection of seismic signals from distant events. The reliability of these stations is not yet as high as desirable but has steadily improved over the past few months. A

wide variety of instrumentation is employed at the current Alpha stations, but although some instrumental effects can be observed these cannot yet be shown to affect detection capability. Many Beta stations are now available but their usage has been low and thus it is not yet possible to assess their capabilities or usefulness in terms of improving event locations. This situation is expected to improve rapidly. An initial assessment shows that the most effective use of some of the existing stations will require the application of corrections to take into account the effects of local geology.

The data communications links employed for the current system appear to be highly reliable and this conclusion is independent of the physical means (satellite, fibre optic, cable, etc) employed for the link. If there are interruptions of the links, procedures to recover missing data have been implemented in most cases. Dedicated links to many countries have excess capacity and could handle a greater data volume, or number of stations, if desired. Several countries are improving access to their Beta stations, and the procedures to retrieve data from them are being thoroughly tested and improved.

5.2 National Data Centres

A brief survey was conducted of those National Data Centres (NDCs) which were participating in GSETT-3 at the end of December 1994. Questionnaires were sent to nineteen NDCs, fourteen of which responded. The information from the completed questionnaires was collected and used to make a preliminary assessment of the performance of the NDCs. It was apparent that a major part of the effort was being put into the monitoring of alpha and beta stations, ensuring the provision of seismological waveform data from their stations to the IDC. Almost all NDCs, with only three exceptions, reported having an Internet connection. This means that the NDCs can access the IDC data base using a variety of techniques. Beta data can be retrieved from some NDCs and stations by the IDC using Internet and dial-up links. The development of an AutoDRM capability at several NDCs has proved to require a considerable amount of effort, and not all have completed this work. All NDCs are willing to be active in GSETT-3 Evaluation work and it is planned that NDC Evaluation Reports will be sent to the IDC starting in March 1995. The information contained in such reports will be used to evaluate many aspects of the GSETT-3 experiment, not the least being costs. It is very difficult to give any idea of definitive costs at this stage but detailed cost information should be available from these NDC Evaluation Reports and this will enable the WGE to make cost estimates for the different components of the GSETT-3 system.

5.3 IDC Quality Assurance Evaluation

Two representatives of the Working Group on Evaluation visited the IDC in Arlington, Virginia the 7th to the 26th of November. The purpose of the visit was to assess the readiness of the IDC to start full scale operation on 1 January, i.e. to perform the Quality Assurance Evaluation described in Annex 1 of Volume 4 of the GSETT-3 documentation. The IDC was then, and is still, under development and some items had to be postponed and others only partially tested, but most items were addressed.

According to the results from the Quality Assurance Evaluation the IDC was ready on 1 January 1995 to process data from the alpha/beta network expected to be in operation at that time. The international manning at the IDC had reached the envisaged level. Reviewed Event Bulletins would be, and are being, generated daily and on schedule and the basic statistics necessary for the evaluation of GSETT-3 are being accumulated. However, for data days containing an excessive number of events the time schedule was sometimes relaxed. The first version of the AutoDRM was tested in a simulated full scale test in which 7 NDCs took part; it proved to be very efficient in answering requests for large data volumes. An internet hyper-

media browser called Mosaic is also available to the NDCs for accessing the IDC archive. All processing steps from the collection of data to the interactive analysis are automatic, with the exception of transferring waveforms to the permanent archive. One to two operators are sufficient to monitor the automatic processing so a high degree of automation has been reached. The design of the IDC is modular and well suited for future modifications and improvements of the system. The total cost of the IDC is $9 million from October 1994 until September 1995, including development, communications, and the support of visiting international staff.

Furthermore, there exists a development plan to increase the capability of the IDC to process data from the larger alpha/beta network envisaged in 1995 and to address questions relevant to an operational IDC such as security, data authentication and full documentation.

5.4 Seismological Issues

It is difficult, given the rapid evolution of the network and frequent changes in procedures, to conduct seismological evaluations in a consistent manner, but some very preliminary conclusions can be drawn from a number of national reports. Those countries that have compared the detection and subsequent processing carried out by the IDC with that which they conduct have found quite good agreement in most cases, although it is clear that the tuning of such processing is a lengthy procedure. It still appears, however, that a high proportion of the phase readings in the bulletins are made by human analysts rather than the automatic processes, and that the latter require further refinement. Similarly, a rather high proportion of the events appearing in the bulletins are created by the analysts, although the ratio of automatic events to those finally appearing in the bulletins has decreased following the adoption of more conservative event definition criteria. National suggestions for more effective criteria are being investigated.

A number of countries have compared locations from their denser national networks with those given in the IDC bulletins. These studies indicate that in most cases the IDC locations are quite good and that the associated error estimates are realistic. Once the gamma data being submitted is actually entered into and available from the IDC database, it will be possible to carry out such analyses in a more systematic manner. Depth estimates in the bulletins are generally good but there were several well-documented instances where the bulletin focal depth was excessive. Several national investigations have compared their magnitudes with those of the IDC and while typically these agree to about half a magnitude unit, it is clear that the issue of magnitudes, and how this will affect assessments of the detection capability of the GSETT-3 network, is an extremely complex one that will require much effort.

Because of the very limited use so far of data from Beta stations, their value for event location and definition is hard to estimate, and a high priority should be given to more effective use of such facilities. Most events appearing in the bulletins are recorded only at teleseismic distances, and the array stations are mostly clearly superior to single stations in terms of detection capability. For the current network, theoretical estimates of detection capability by the IDC appear to be in quite good agreement with national estimates for regions as diverse as western Europe, Japan and New Zealand. These theoretical capabilities vary widely across the globe, reflecting the quite uneven distribution of stations, with coverage so far being quite poor in Africa, much of Asia, and South America.

5.5 Evaluation Plans

Overall, there have been substantial improvements in both capability and procedures during the first two months of 1995, but much work remains

to be done. The WGE intends to improve coordination with both the NDCs and the IDC, and to develop a plan that should lead to firmer conclusions about the present system and how it might be improved. Particular attention will be paid to issues such as capability, costs, the value of Beta stations, and the magnitude consistency problem. A special effort is being made to collect information on national and regional networks and procedures and to establish standard techniques for comparison of event locations and magnitudes from such networks with those produced by the IDC. The WGE will meet again just before the next GSE session in order to provide an up-to-date report on these and other matters.

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